Cognition 109 (2008) 316–325

Contents lists available at ScienceDirect

Cognition

journal homepage: www.elsevier.com/locate/COGNIT

Tight and *loose* are not created equal: An asymmetry underlying the representation of *fit* in English- and Korean-speakers

Heather M. Norbury [a,*], Sandra R. Waxman [a,1], Hyun-Joo Song [b,2]

[a] *Department of Psychology, Northwestern University, 2029 Sheridan Road, Evanston, IL 60208, USA*
[b] *Department of Psychology, Yonsei University, 134 Shinchon-dong, Seodaemon-gu, Seoul 120-749, South Korea*

ARTICLE INFO

Article history:
Received 21 April 2008
Revised 29 July 2008
Accepted 30 July 2008

Keywords:
Language and thought
Spatial representation
Conceptual representation

ABSTRACT

Research concerning the spatial dimension *fit* (*tight* versus *loose*) has been based on a tacit but untested assumption that the dimension *fit* is symmetrical, with tight- and loose-fitting relations highlighting the dimension *fit* with equal force. We propose a reformulation, documenting that adult speakers of English (Experiment 1) and Korean (Experiment 2) are sensitive to the dimension *fit*, but that their representation is asymmetric, with tight-fitting events highlighting *fit* with greater force than loose-fitting events. We propose that sensitivity to the dimension *fit* is more resilient than has previously been suggested, and that the asymmetry documented here provides a foundation upon which to pursue nuanced questions about the relationship between language and our underlying representations of space.

1. Introduction

Some of the most captivating questions in cognitive psychology consider how our most fundamental concepts (e.g., time and space) are represented and whether our representations are shaped by the language that we have acquired. In crafting answers to these questions, researchers have adopted very different perspectives. At one extreme lies the suggestion that human languages differ profoundly, that language exerts a strong influence on underlying conceptual representations, and that as a result, when cross-linguistic differences arise, they are accompanied by concomitant differences in underlying representations (Whorf, 1956). At the other extreme lies the suggestion that human languages differ little (if at all) in their representational capacities (Chomsky, 1986), that language exerts a minimal influence on non-linguistic representations, and that as a result, speakers of different languages share strong convergences in their underlying representations (Gennari, Sloman, Malt, & Fitch, 2002; Li & Gleitman, 2002; Malt, Sloman, Gennari, Shi, & Wang, 1999; Munnich, Landau, & Dosher, 2001; Papafragou, Massey, & Gleitman, 2002). Between these lie a host of intermediate perspectives, which vary in their characterization of cross-linguistic differences and in their articulation of whether these differences influence the underlying non-linguistic representations (e.g., Boroditsky, 2001; Davidoff, Davies, & Roberson, 1999; Hespos & Spelke, 2004; Imai & Gentner, 1997; Levinson, 1996; Lucy, 1992; McDonough, Choi, & Mandler, 2003; Slobin, 1996).

Despite these differences in perspective, research programs in this area follow virtually the same logical approach. First, two (or more) languages are identified that differ in a potentially relevant way. Then, non-linguistic tasks are designed to discover whether this difference in the domain of language has consequences on speakers' conceptual representations.

The success of this approach rests upon the accuracy with which both the relevant linguistic phenomena and

* Corresponding author. Tel.: +1 847 467 8932; fax: +1 847 491 7859.
E-mail addresses: norbury@northwestern.edu (H.M. Norbury), s-waxman@northwestern.edu (S.R. Waxman), hsong@yonsei.ac.kr (H.-J. Song).
[1] Tel.: +1 847 467 2293; fax: +1 847 491 7859.
[2] Tel.: +82 2123 2449; fax: +82 365 4354.

0010-0277/$ - see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.cognition.2008.07.019

the underlying conceptual representations are characterized. In this paper, we focus on the representations underlying adults' spatial concepts pertaining to *fit*. We begin with a review of recent linguistic and psychological evidence, pointing out that this work has rested upon a tacit but untested assumption that the dimension *fit* is symmetric, with tight- and loose-fitting events drawing attention to this dimension with equal force. We propose an alternative, suggesting that our underlying representation of *fit* is asymmetric, with tight-fitting events drawing attention to *fit* more powerfully than loose-fitting events. We then provide evidence for this proposal with adult speakers of English (Experiment 1) and Korean (Experiment 2).

Several researchers have described an intriguing cross-linguistic difference in how the concept *fit* is 'packaged' in the lexicon (Bowerman & Choi, 2001; Choi & Bowerman, 1991; Choi, McDonough, Bowerman, & Mandler, 1999; McDonough et al., 2003). Consider Fig. 1. Speakers of English typically describe the events depicted in A and B as "in" and those depicted in C and D as "on". For speakers of Korean, the events depicted in A and C are typically described as tight (the Korean term "kkita" is glossed in English as "to put together tightly"; "to interlock") and those depicted in B and D as loose (the Korean term "nehta" is glossed as "to put loosely in or around"; the term "nohta" is glossed as "to put loosely on a horizontal surface"). The claim is that in describing events like these, speakers of English may, as an option, specify tightness-of-fit (by using an adverb, e.g., 'loosely'; 'snugly'), but that for speakers of Korean, specifying tightness-of-fit is not optional because information about *fit* is inherent in the very meanings of these verbs (e.g., Bowerman & Choi, 2001; but see Kawachi, 2007).

Building upon these observations, researchers have asked whether this cross-linguistic difference is reflected in speakers' non-linguistic representations of the dimension *fit*. The evidence to date suggests that it is. For example, pre-linguistic infants appear to distinguish among all four spatial relations depicted in Fig. 1 (Casasola & Cohen, 2002; Casasola, Cohen, & Chiarello, 2003; Hespos & Spelke, 2004; McDonough et al., 2003). They thus appear to be poised to acquire the semantics of Korean, English or any other human language. However, the evidence from adults suggests that their performance on non-linguistic tasks may vary with the language they have acquired: adult speakers of Korean apparently attend to tightness-of-fit, but adult speakers of English apparently do not (Hespos & Spelke, 2004; McDonough et al., 2003).

These findings have been interpreted as evidence for 'conceptual tuning', and have been likened to a phenomenon in speech perception known as 'perceptual tuning': infants are initially sensitive to all possible phonemic contrasts, but their ability to distinguish non-native phonemic contrasts diminishes as a function of exposure to their native language (e.g., Best, 1995; Kuhl, 1998; Werker & Tees, 1984). The possibility that there is 'conceptual tuning' in the domain of spatial relations is intriguing, but if we are to discover whether and how native language semantics 'tune' the conceptual representation of *fit*, it is essential that we capture this underlying representation with sufficient accuracy and precision. We therefore take a closer look at adults' representation of *fit*.

Research on this topic has been based on an (untested) assumption that the representation underlying the dimension *fit* is symmetric, but there is reason to suspect that this may not be the case, and that tight-fitting events draw attention more forcefully to *fit* than do loose-fitting events. For example, when two entities fit together tightly, the spatial relation between them is quite specific: all or most of their surfaces are in snug contact. But when two objects fit together loosely, the spatial relation between them is, in fact, underspecified: their surfaces may or may not be in contact. Moving beyond observation, a review of the linguistic evidence offers further reason to suspect that there may be an asymmetry in our representations of *fit*. For example, for the spatial relations depicted in Fig. 1, Korean-speakers apparently require only a single word, *kkita*, to describe a tight-fitting event (whether it involves support or containment), but require (at least) two different words to describe a loose-fitting event, *nehta* for loose containment and *nohta* for loose support. This fact – that in a language that marks fit explicitly within the lexicon, more terms are required to describe loose-fitting than tight-fitting events – is consistent with the observation that tight-fitting events may provide more precise information about the spatial relation between participant objects than do loose-fitting events.

There are also hints that in non-linguistic tasks, tight-fitting events may guide attention toward *fit* with greater precision and force than do loose-fitting events. Despite broad interest in the topic of spatial representations, to the best of our knowledge, only two empirical investigations of adults' sensitivity to *fit* have been reported (Hespos & Spelke, 2004; McDonough et al., 2003). Because both were based on a tacit assumption of underlying symmetry, the question that they asked was whether participants would attend to *fit* in a general sense, not whether they would be more attentive to *fit* in the context of tight- than loose-fitting relations. For example, McDonough et al. (2003) gathered English- and Korean-speaking adults' responses to support and containment events involving tight- and loose-fit. But in reporting their results, they averaged over the tight- and loose-fitting events, providing a composite index of speakers' sensitivity to *fit*. They reported that adult speakers of Korean, but not English, were sensitive to *fit*. On the basis of the averages that they report, it is not possible to consider the possibility that adult speakers of either language were more sensitive to *fit* in the context of tight- than loose-fitting events. However, Hespos and Spelke (2004) reported the results for tight- and loose-fitting events independently. Although English-speaking adults did not reliably demonstrate attention to *fit* in any condition, a careful examination of their results suggests that attention to *fit* was more pronounced when participants had been familiarized to tight- than to loose-fitting events. This is consistent with our suggestion that English-speaking adults may indeed represent the underlying dimension *fit*, and may do so in an asymmetric fashion.

In the current experiments we consider this possibility directly. We focus first on English-speaking adults because they provide the strongest test case: Although explicit mention of *fit* is optional when describing events in this

language, we predict that adult speakers may nonetheless be sensitive to *fit*, with tight-fitting events guiding their attention to *fit* with greater force than loose-fitting events.

2. Experiment 1

To test the hypothesis that tight-fitting events guide attention to *fit* more powerfully than loose-fitting events, we adopted a similarity judgment task patterned closely after Hespos and Spelke (2004). See Fig. 2.

2.1. Method

2.1.1. Participants

Participants were 64 Northwestern University undergraduates (38 females), ranging from 17 to 22 years (M = 19.81). Seventy-nine percent were White, 15% Asian, and less than 1% Black. All were native English-speakers.[3]

2.1.2. Materials

Fig. 2 describes the materials presented in this experiment.[4]

2.1.3. Procedure

Participants were seated in a quiet testing room, four feet from a stage on which the experimental events took place. An experimenter described the task and then moved behind a barrier for the remainder of the session.

2.1.3.1. Practice trials. To familiarize them with the structure of the task, participants first completed two practice trials, identical in structure to the experimental trials, but featuring single abstract shapes rather than spatial events (described below).

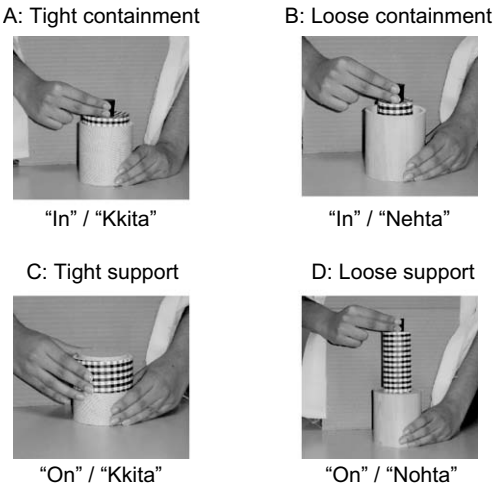

Fig. 1. English and Korean terms for four distinct spatial relations.

2.1.3.2. Experimental trials. Participants then completed four experimental trials, each composed of a familiarization and test phase (Fig. 2). No feedback was provided. Trial order was determined by Latin-square.

2.1.3.2.1. Familiarization phase. Each familiarization phase featured one type of spatial event (Tight-In, Loose-In, Tight-On, or Loose-On). To begin each trial, the experimenter's hands appeared from behind a backdrop. She placed one object (a container, pedestal or post) on the stage, then placed a second object in its specified relation to the first, and then removed it. For example, on the Tight-In trial, she placed a container on the stage, placed a cylinder tightly inside it, and then removed it. This sequence was repeated six times.

2.1.3.2.2. Test phase. Next, the experimenter presented a Loose-In and Tight-In test event. The same two test events appeared on all trials; they appeared in alternating order across trials. Participants used a 10-point scale to rate the similarity of each test event to the familiarization event that preceded it.

2.2. Predictions

If participants attended to *fit* during familiarization, then the test event that matched the familiarization event for *fit* should receive a higher similarity rating than the test event that did not. For example, if participants attended to *fit* during the Tight-In familiarization events, then at test they should provide a higher similarity rating for the Tight-In than the Loose-In test event. If participants did not attend to *fit*, their ratings for two test events should not differ.

Thus, if tight-fitting relations draw attention to *fit* more powerfully than loose-fitting relations, then (1) when participants view tight-fitting events during familiarization, they should provide a higher similarity rating for the Tight-In than the Loose-In test event, but (2) when they

[3] Seven participants in Experiment 1 and two in the follow-up had acquired another language concurrently with English, but had spoken predominantly English for more than 15 years. None spoke Korean or were from a Korean cultural background. We report on analyses that include data from all participants. However, when only monolingual participants were included, the same main effects and interactions emerged.

[4] In designing the objects, we sought to minimize the possibility that participants would systematically use the width or color of any single object, rather than the spatial relations between two objects, as the basis for their similarity judgments. To minimize their use of width, each familiarization event featured a 3-in. wide base object (container, pedestal, or post); for the tight-in test event, the corresponding base object was either 1.5 in. wide (a reduction of 50%); for the loose in test event, the corresponding base object was 4.5 in. wide (an increase of 50%). To minimize their use of color, the color of the base object (container, pedestal or post) varied randomly for every event within each trial (six familiarization events; two test events).

The *relative* widths of the stimulus objects present a potential confounding factor: when the familiarization objects fit tightly, the ratio of their widths (approximately 1:1) was identical to that of the tight-fitting test pair. However, when the familiarization objects fit loosely, the ratio of their widths (approximately 1:2) was different from that of the loose-fitting test pair (approximately 1:3). These ratios might bias participants toward the asymmetric responses we describe. However, in an unrelated set of experiments, Hespos (personal communication, 2007) had participants complete a task identical to ours with one exception: the familiarization objects were not placed into tight or loose spatial relations; rather one object occluded the other. If size and not fit were driving the asymmetry, Hespos would have found asymmetric responses between trials in which the stimulus objects were similarly sized and those in which they were not. In fact, she did not find an asymmetry. This suggests that our results stem from participants' attending to the relations between objects and not to their relative size.

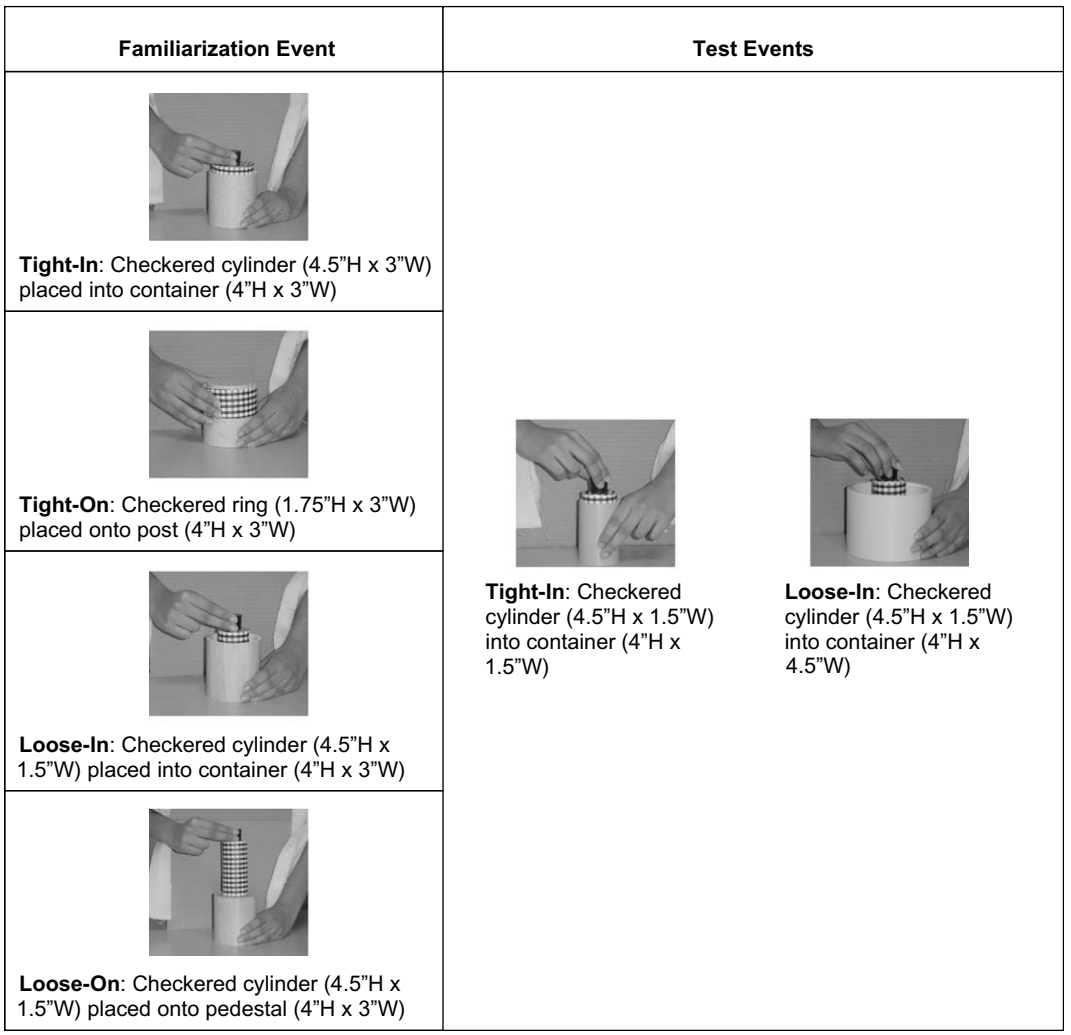

Fig. 2. Experiment 1: structure of the experimental design.

view loose-fitting events during familiarization, their ratings for the test events should not differ.

2.3. Results and analysis

2.3.1. First trial

We first considered participants' performance on their first trial only. This provides a point of comparison with Hespos and Spelke (2004) and with Experiment 2. We submitted similarity ratings from participants' first trial to an analysis of variance, using fit-at-familiarization (2: Tight versus Loose) and location-at-familiarization (2: In versus On) as a between-participants factors and test event (2: Tight-In versus Loose-In) as a within-participants factor. See Fig. 3. There was a main effect for location-at-familiarization, $F(1,62) = 29.20$, $p < .0001$; $\eta_p^2 = .32$, indicating that participants were sensitive to the distinction between support and containment: similarity ratings for the two (In) test events were higher following familiarization events involving In ($M = 6.98$) than involving On ($M = 5.19$). A main effect for test event, $F(1,62) = 31.18$, $p < .0001$; $\eta_p^2 = .37$, revealed that participants' similarity ratings were higher for the Tight-In ($M = 6.54$) than the Loose-In test event ($M = 5.66$). This was qualified by a test event by fit-at-familiarization interaction, $F(1,61) = 43.23$, $p < .0001$; $\eta_p^2 = .42$. Tests of simple main effects revealed that when participants were familiarized to tight-fitting events, they attended to *fit*, providing higher similarity ratings for the Tight-In than the Loose-In test event ($M = 6.85$ and 5.03, respectively, $F(1,61) = 79.33$, $p < .0001$; $\eta_p^2 = .18$). However, when participants were familiarized to loose-fitting events, their ratings for the two test events did not differ, $F(1,61) = .21$, $p > .05$; $\eta_p^2 = .04$.

2.3.2. All trials

An analysis of participants' ratings on all four trials yielded the same main effects (location-at-familiarization, $F(1,62) = 244.12$, $p < .0001$; $\eta_p^2 = .80$; test event, $F(1,62) = 53.18$, $p < .0001$; $\eta_p^2 = .46$) and interaction (test event by fit-at-familiarization, $F(1,62) = 53.18$, $p < .0001$;

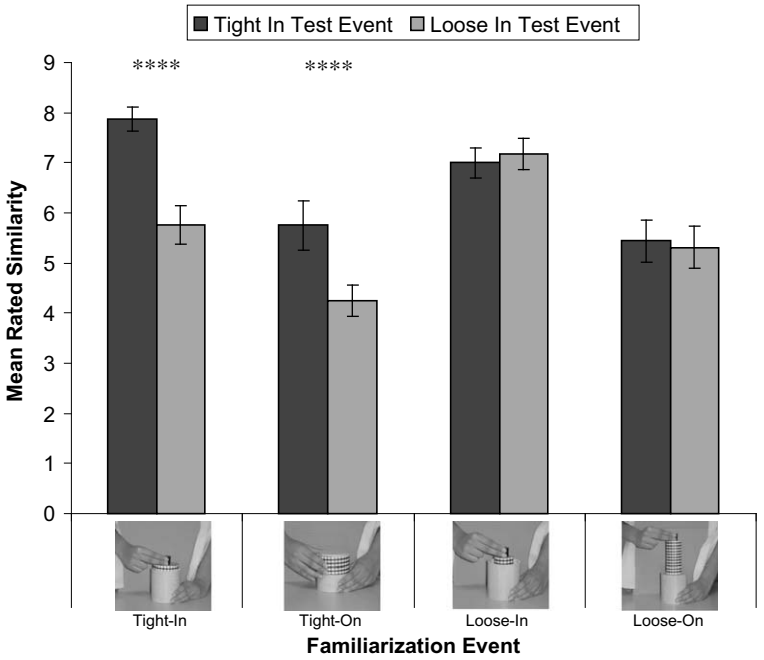

Fig. 3. Experiment 1 (first trial data): similarity judgments as a function of fit- and location-at-familiarization; $^{****}p < .0001$.

$\eta_p^2 = .55$). However, this was qualified by an interaction between test event, fit-at-familiarization and location-at-familiarization, $F(1,62) = 26.16$, $p < .001$; $\eta_p^2 = .30$. Tests of simple main effects revealed that when participants were familiarized to tight-fitting events, they were attentive to *fit* (Tight-In familiarization trial, $F(1,62) = 79.09$, $p < .0001$; $\eta_p^2 = .56$; Tight-On familiarization trial, $F(1,62) = 56.92$, $p < .0001$; $\eta_p^2 = .48$). However, when participants were familiarized to loose-fitting events, performance was inconsistent (see Fig. 4). When they viewed Loose-On familiarization events, participants rated the test events as comparable, $F(1,62) = 2.88$, $p > .05$; $\eta_p^2 = .04$. Yet when they viewed Loose-In familiarization events, they attended to *fit*, their rating of Tight-In ($M = 6.51$) test event exceeded that of the Loose-In test event ($M = 7.23$), $F(1,62) = 10.72$, $p < .01$; $\eta_p^2 = .15$.

Participants may have been most likely to attend to *fit* when location remained constant throughout the trial; indeed, they were more attentive to *fit* during the Tight-In than the Tight-On trial, $F(1,62) = 11.20$, $p < .01$; $\eta_p^2 = .15$. Thus, if participants were to attend to fit on any Loose trial, we would expect them to do so for the Loose-In trial, and not the Loose-On trial. Still, if our proposal is correct, and loose events do not effectively draw attention to fit, what accounts for participants' unexpected attention to fit on the Loose-In trial? A strong possibility is that their performance on the Loose-In trial was related to their exposure to tight-fitting relations on a preceding trial.

To address this issue, we selected participants who viewed the Loose-In familiarization event in their second trial ($n = 16$); half of these had completed the Tight-On trial just prior and half had completed the Loose-On trial. Performance on the Loose-In trial varied as a function of the preceding trial. Those who first viewed a Tight-On trial attended reliably to *fit* on their subsequent Loose-In trial, $F(1,14) = 5.88$, $p < .05$; $\eta_p^2 = .40$, but those who first viewed a Loose-On trial did not, $F(1,14) = 3,77$, $p > .05$; $\eta_p^2 = .21$.

This suggests that experience with a tight-fitting event is sufficiently powerful to draw participants' attention to *fit* on a subsequent trial involving a loose-fitting event. Because participants in both conditions completed the same number of trials, it was not experience with the task in general that heightened their attention to *fit*. Moreover, experience with one loose-fitting event did not boost participants' attention to *fit* on a subsequent loose-fitting event, but experience with one tight-fitting event did.

2.3.2.1. Follow-up experiment. We sought to replicate this finding with an independent sample and to gain insights from participants' justifications of their choices. Participants were 32 Northwestern University undergraduates (19 females), ranging from 18 to 20 years ($M = 19.07$). Participants were 90% White and 10% Asian. All were native English-speakers.[1] The procedure and materials were identical to Experiment 1, except that all participants completed only two trials. Participants were randomly assigned to view either the Tight-On or Loose-On events on their first trial. For all participants, the second trial was the Loose-In trial. After completing the second trial, participants were asked to justify their similarity ratings. Justifications were recorded verbatim and then coded by two independent coders for reference to "tightness," "snugness," and "fit," etc.

The results replicate the finding that tight-fitting events draw attention to *fit* more powerfully than do loose-fitting events, and that attention to *fit* carries over from a Tight to a

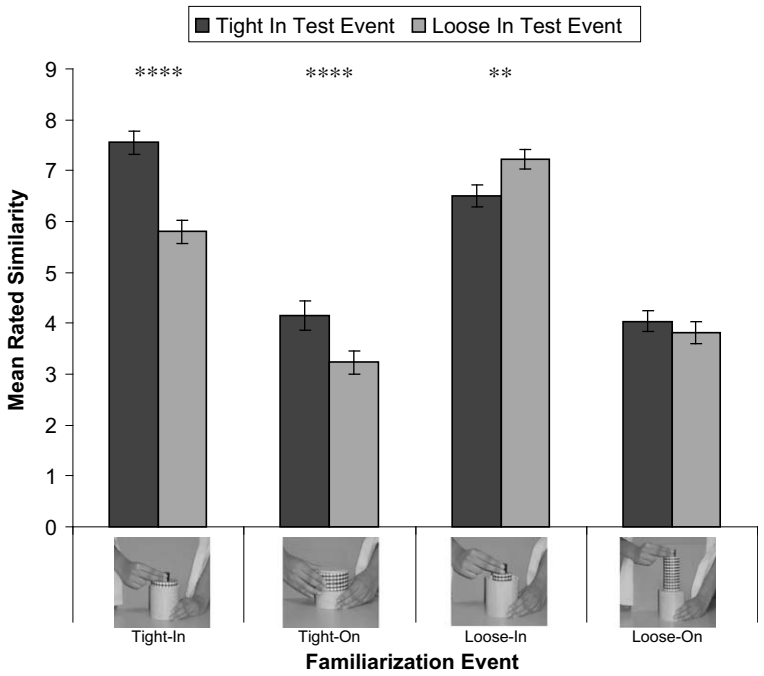

Fig. 4. Experiment 1 (all trials): similarity judgments as a function of fit- and location-at-familiarization; $^{**}p < .01$ and $^{****}p < .0001$.

subsequent Loose familiarization trial. We submitted participants' similarity ratings to an ANOVA, using condition (Tight-first versus Loose-first) as a between-participants factor, and trial position (first versus second trial) and test event (Tight-In versus Loose-In) as within-participants factors. There was a main effect for trial position, $F(1,30) = 45.26$, $p < .001$; $\eta_p^2 = .60$; a condition by test event interaction, $F(1,30) = 11.08$, $p < .01$; $\eta_p^2 = .16$; and a trial position by test event interaction, $F(1,30) = 8.20$, $p < .01$; $\eta_p^2 = .27$. These effects were all mediated by a condition by trial position by test event interaction, $F(1,30) = 8.20$, $p < .01$; $\eta_p^2 = .22$.

We pursued this interaction by conducting tests of simple effects, focusing on performance on each trial. As predicted, on their first trials, participants in the Tight-first condition attended to *fit*, $F(1,30) = 20.43$, $p < .0001$; $\eta_p^2 = .41$, but those in the Loose-first condition did not, $F(1,30) = .82$, $p > .05$; $\eta_p^2 = .03$. This converges perfectly with the first trial analysis of Experiment 1. Also as predicted, participants' performance on their second (Loose-In) trial was influenced by their preceding experience. Participants in the Tight-first condition attended reliably to *fit* on their subsequent Loose-In trial, $F(1,30) = 6.70$, $p < .05$; $\eta_p^2 = .18$; participants in the Loose-first condition did not, $F(1,30) = 1.91$, $p > .05$; $\eta_p^2 = .06$.

Participants' justifications provided converging support that the dimension *fit* is signaled more powerfully in the context of tight- than loose-fitting events. In the Tight-first condition, 8 of the 16 participants mentioned *fit* explicitly; in the Loose-first condition, only two did so, $\chi^2(1, N = 32) = 5.24$, $p < .05$. Interestingly, of the participants mentioning *fit*, fully 50% commented on the presence or absence of *fit* (e.g., "The second one was more similar *because it fit*."); none mentioned "tight-fit" versus "loose-fit."

Experiment 1 reveals for the first time that the representation underlying *fit* is more resilient in English-speakers than previous research has suggested. Despite the fact that specifying tightness-of-fit is optional for English-speakers when they describe events like the ones presented here, participants were indeed sensitive to this dimension, and tight-fitting events highlighted attention to fit with greater force than loose-fitting events. In Experiment 2, we turn to consider the representations held by Korean-speakers.

3. Experiment 2

The goal of Experiment 2 was to consider adult Korean-speakers' representation of the dimension *fit*. To the best of our knowledge, there is only a single study (McDonough et al., 2003) that examined attention to *fit* in Korean-speaking adults. As we have pointed out, this study did not assess whether their attention to fit was signaled more powerfully with tight- than loose-fitting events. Based on the asymmetry documented in speakers of English (Experiment 1), we expect that adult speakers of any language will attend to *fit* when presented with tight-fitting events. At issue is whether the semantic properties of Korean are sufficiently powerful to direct attention to *fit* in the context of loose-fitting events as well. Although cross-linguistic analyses have noted that when describing events (as in Fig. 1), tightness-of-fit may be more accessible to speakers of Korean than English, what is less clear is whether and how this linguistic fact would effect, in any direct way, the underlying non-linguistic representation of *fit* (Gennari

et al., 2002; Landau, in press; Munnich et al., 2001; Papafragou et al., 2002).

3.1. Method

3.1.1. Participants

Participants were 64 undergraduates (27 females) at Yonsei University in Seoul, South Korea. All were native Korean-speakers. None spoke English fluently.

3.1.2. Materials and procedure

These were identical to Experiment 1, except that (a) the experiment was administered in Korean by a native speaker, (b) participants completed only one trial instead of four, and (c) the practice trials were eliminated.

3.2. Results

Korean-speaking adults' performance mirrored precisely those of their English-speaking counterparts. An ANOVA, using fit-at-familiarization (Tight versus Loose) and location-at-familiarization (In versus On) as a between-participants factors and test event (Tight-In versus Loose-In) as a within-participants factor revealed the same main effects and interactions as in Experiment 1. See Fig. 5. A main effect for location-at-familiarization, $F(1,62) = 9.25$, $p < .01$; $\eta_p^2 = .13$, revealed that ratings for the two (In) test events were higher following familiarization events involving In ($M = 7.13$) than On ($M = 5.48$). This documents that Korean-speakers are sensitive to the distinction between support (On) and containment (In) events, despite the fact in describing tight-fitting events (with *kkita*), Korean-speakers do not distinguish support from containment. A main effect for test event, $F(1,62) = 9.59$, $p < .01$; $\eta_p^2 = .14$, revealed that similarity ratings were higher for the Tight-In ($M = 6.56$) than the Loose-In test event ($M = 6.05$). This was qualified by a interaction between test event and fit-at-familiarization, $F(1,61) = 24.74$, $p < .0001$; $\eta_p^2 = .29$. A test of simple main effects revealed that, as predicted, when participants were familiarized to tight-fitting events, they attended to *fit*: they provided higher average similarity ratings for the Tight-In than the Loose-In test event ($M = 6.72$ and 5.38, respectively, $F(1,61) = 32.57$, $p < .0001$; $\eta_p^2 = .35$). However, when participants were familiarized to loose-fitting events, they did not: there was no difference in their average ratings for the Tight-In and Loose-In test events ($M = 6.41$ and 6.72, respectively, $F(1,61) = 1.72$, $p > .05$; $\eta_p^2 = .03$).

Finally, we compared the performance of Korean- and English-speakers, in an ANOVA, using language (English: Experiment 1 versus Korean: Experiment 2), fit-at-familiarization (Tight versus Loose), and location-at-familiarization (In versus On) and as between-participants factors, and test event (Tight-In versus Loose-In) as a within-participants factor. There were no main effects or interactions involving language (main effect for language, $F(1,120) = .38$; language by fit-at-familiarization interaction, $F(1,120) = .10$; language by location-at-familiarization, $F(1,120) = .10$; language by test event, $F(1,120) = 2.20$; language by fit-at-familiarization by location-at-familiarization, $F(1,120) = 1.22$; language by fit-at-familiarization by test event, $F(1,120) = .24$; language by location-at-familiarization by test event, $F(1,120) = .01$; language by fit-at-familiarization by location-at-familiarization by test event, $F(1,120) = .01$).

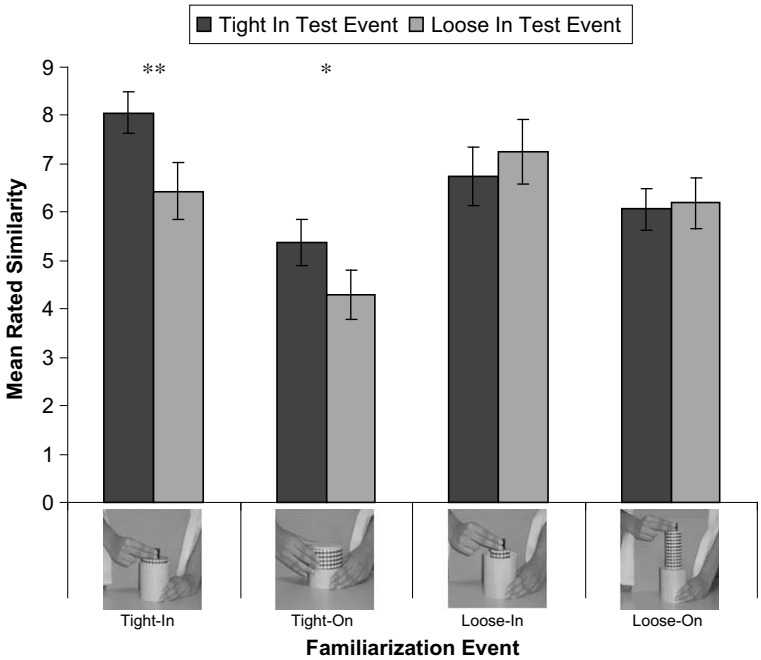

Fig. 5. Experiment 2: similarity judgments as a function of fit- and location-at-familiarization; $^{*}p < .05$ and $^{**}p < .01$.

4. General discussion

These experiments reveal for the first time that the conceptual representation underlying *fit* is asymmetric, with tight-fitting events drawing attention to *fit* with greater force than loose-fitting events. The evidence from English-speaking adults is important because it reveals the representation underlying *fit* is more resilient, and more nuanced, than previous research (Hespos & Spelke, 2004; McDonough et al., 2003) has suggested. Despite the fact that they need not mention *fit* explicitly in their description of events, English-speakers are nonetheless sensitive to this dimension, and particularly in the context of tight-fitting events. The evidence from Korean-speaking adults is important because it reveals that despite the fact that speakers of this language explicitly specify both tight- and loose-fit in their descriptions of events (e.g., Choi & Bowerman, 1991), their non-linguistic representation underlying *fit* is nonetheless asymmetric. Moreover, despite the fact that they need not specify whether a tight-fit involves support or containment, Korean-speakers are nonetheless sensitive to this distinction. Thus, although the English and Korean languages differ in the ways in which they encode spatial and motion events, speakers of these languages do not appear to differ in their non-linguistic representations of the dimension *fit*. This is consistent with the view that our sensitivity to *fit* is not a consequence of the language we have acquired (see Gennari et al., 2002; Munnich et al., 2001; Papafragou et al., 2002). In both English (Experiment 1) and Korean (Experiment 2), this underlying representation is asymmetric.

4.1. Accounting for differences between the current results and previous investigations

How can we account for the finding that English-speakers were sensitive to *fit* in the current, but not previous, experiments? And why might Korean-speakers, like English-speakers, show a tight-loose asymmetry? We suspect that these differences reflect the question that the experiments were designed to address. In previous work, the question was whether participants would attend to *fit* in a general sense. Our question differed subtly, but importantly. We asked whether the representation underlying *fit* was symmetric, and designed our analyses to ask whether participants might be more attentive to *fit* in the context of tight- than loose-fitting events. Using Hespos and Spelke (2004) as a starting point, we introduced several modifications. For example, although we preserved precisely the spatial dimensions of their materials, we modified their color in an effort to minimize participants' attention to anything other than *fit*. Importantly, these design modifications – featured on all trials and in both languages – did not lead participants to attend to *fit* on all trials. Instead, participants attended reliably to *fit* only in the context of all tight-fitting events.

4.2. Characterizing the asymmetry

To the best of our knowledge, this is the first time that a representational asymmetry underlying *fit* has been proposed and the first time that this issue has been brought into contact with research on language and thought. However, the tight-loose asymmetry documented here is compatible, at least in spirit, with several other well-established asymmetries, including those involving focal versus non-focal colors, canonical versus non-canonical line orientation, known versus unknown landmarks, and familiar versus unfamiliar entities (e.g., Bowdle & Gentner, 1997; Holyoak & Gordon, 1983; Huttenlocher, Hedges, & Duncan, 1991; Karylowski, 1990; Medin & Waxman, 2007; Nosofsky, 1991; Rips, 1975; Rosch, 1975; Sadalla, Burroughs, & Staplin, 1980; Treisman & Souther, 1985; Tversky, 1977). Taken together, the evidence suggests that asymmetries arise in tasks that involve comparisons (implicit or explicit) between two elements, one of which enjoys greater psychological privilege or salience than the other.

In future work, it will be important to characterize the tight-loose asymmetry more precisely and to discover whether and how it is related to linguistic, perceptual and conceptual factors. We suspect that it is not *created* by language. For example, we would be hard-pressed to identify any features of English that could have created it. This asymmetry is more likely to be related to perceptual and conceptual factors. In particular, when two entities fit together tightly, the physical relation between them is quite specific: their surfaces are in close contact. But when two objects are in a loose spatial relation, the physical relation between them is vastly underspecified: their surfaces may or may not be in contact (compare, e.g., an apple placed in a briefcase versus a shopping bag). Moreover, when two entities fit together tightly, they were often designed to do so. This is less reliably the case for entities that fit together loosely. This raises the intriguing possibility that tight-fitting relations may gain psychological prominence by virtue of the correlation between tightness-of-fit and intended function (Bloom & Markson, 1998; Booth, 2006; Casler & Kelemen, 2005; Diesendruck, Markson, & Bloom, 2003; Keil, 1989; Kemler Nelson, Herron, & Holt, 2003; Matan & Carey, 2001).

These observations, coupled with the results reported here, suggest that the continuum of spatial relations underlying *fit* may be better described as *fits* versus *does not fit* than as *tight* versus *loose*. Munnich et al. (2001) propose an analogous view of *contact* versus *no contact*. Indeed, events involving tight-fit and direct contact may serve as strong reference points, providing clear standards against which other points along their respective continua may be measured (see Leslie, 1984; Needham & Baillargeon, 1993).

Can the evidence of a tight-loose asymmetry in adults' underlying representation of *fit* be reconciled with the notion of 'conceptual tuning'? In our view, the answer is 'yes': interpreting the asymmetry underlying *fit* within the framework of conceptual tuning leads to precise developmental and cross-linguistic predictions. For example, it predicts that tight-fitting events may highlight the dimension *fit* robustly, with or without the explicit support of language, but that loose-fitting events (which may be psychologically or perceptually less privileged) may depend more upon the semantics of the ambient language (Casasola, 2005). Although we have shown for adult speakers of

Korean, that the spatial semantics of their language is not sufficiently powerful to outweigh an underlying tight-loose asymmetry, it remains to be seen whether a language-specific effect may be evident in other non-linguistic tasks.

4.3. Avenues for additional research

At a more general level, a comprehensive resolution to questions concerning the relation between linguistic and non-linguistic representations of *fit* awaits additional evidence from three inter-related areas. First, it will be important to discover whether infants' and toddlers' representation of *fit* is symmetric or asymmetric. Hespos and Spelke's (2004; Fig. 1b) data from 5-month-old infants suggests that the pre-linguistic representation may, in fact, be asymmetric. When infants were habituated to tight-fitting events, they attended reliably and consistently to *fit*. But when they were habituated to loose-fitting events, performance was inconsistent: they attended to *fit* after viewing Loose-In events, but not after Loose-On events. This echoes the pattern we observed in Experiment 1.

However, Choi's (2006) developmental data presents a different picture. She reported that English- and Korean-acquiring toddlers, ranging from 18 to 24 months of age, were equally sensitive to *fit* in the context of both tight- and loose-fitting events. However, Choi suggested that several months later, toddlers' sensitivity to *fit* in the two language communities begins to diverge. At 29–36 months of age, Korean-acquiring toddlers maintained their sensitivity to *fit* in the context of both tight- and loose-fitting events, but within this same developmental period, English-acquiring toddlers' attention to *fit* weakened. A closer examination revealed that English-acquiring toddlers were more likely to attend to *fit* if they had been familiarized to tight- than to loose-fitting events. This finding, although unanticipated by Choi, is consistent with the position that we have advanced here.

Clearly, additional cross-linguistic, developmental research on infants' and toddlers' representation of *fit* will be necessary to resolve whether infants' pre-linguistic representation is symmetric or asymmetric and how this representation fares as infants acquire the semantics of their native language. Such evidence, important in its own right, is essential if we are to understand whether and how language shapes the pre-linguistic representation.

Second, additional research from adults is warranted. Although both English- and Korean-speakers revealed a tight-loose asymmetry in the similarity judgment task presented here, it remains to be seen whether this asymmetry holds up in both languages across a broader range of tasks. One possibility is that for speakers of English, the asymmetry will be present in a broad range of tasks, but that for Koreans, whose language lexicalizes the distinction between tight- and loose-fit, the asymmetry will be less pronounced in some tasks than in others. It will also be important to examine adult speakers of languages other than English and Korean to ascertain whether across languages, attention to *fit* is signaled more powerfully with tight- than loose-fitting events.

Third, it is essential that we develop a more comprehensive analysis of the ways in which spatial relations are lexicalized across languages. Choi and Bowerman's (1991) insight that languages 'package' spatial relations differently was instrumental, but several issues remain unresolved. For example, the relevant spatial terms (*kkita*; *nehta*; *nohta*) are lexicalized as verbs in Korean, but as prepositions (*in*; *on*), adjectives (*tight*; *loose*), or verbs (*fits; does not fit*) in English. It remains unclear whether speakers' construals of the relevant terms are affected differentially as a function of their grammatical form. It is also not entirely clear how to most accurately characterize the semantics of the Korean spatial terms. The assertion that the Korean lexical items include specific reference to *fit* (as suggested by Choi and Bowerman (1991)) has recently been called into question (Kawachi, 2007).

Finally, while considerable attention has been devoted to the question of whether and how the language that we speak structures our representations of space, the reciprocal question is compelling as well. We are now in a position to ask whether and how the asymmetric representation of *fit* influences language. This underlying asymmetry may be reflected in speakers' descriptions of *fit* across languages (Norbury & Waxman, in preparation). The asymmetry that we have reported here may also give rise to developmental differences in lexical acquisition: infants may learn words referencing *tight-fit* earlier than those referencing *loose-fit*.

In closing, as we continue to investigate the relation between the language that we speak and our non-linguistic representations of *fit*, it is essential that we capture both the linguistic and conceptual phenomena with precision.

Acknowledgements

This research was supported by an IES training grant to Norbury and NIH R01 HD30410 to Waxman. Portions of this research were presented at the meetings of the Cognitive Development Society (2005) and the Cognitive Science Society (2006). We are indebted to D. Medin and E. Leddon for extensive discussions, and to S. Hespos for insights into all phases.

References

Best, C. T. (1995). Learning to perceive the sound patterns of English. In C. Rovee-Collier & L. P. Lipsitt (Eds.), *Advances in infancy research* (pp. 217–304). Norwood, NJ: Ablex.

Bloom, P., & Markson, L. (1998). Intention and analogy in children's naming of pictorial representations. *Psychological Science, 9*(3), 200–204.

Booth, A. E. (2006). Object function and categorization in infancy: Two mechanisms of facilitation. *Infancy, 10*(2), 145–169.

Boroditsky, L. (2001). Does language shape thought? Mandarin and English speakers' conceptions of time. *Cognitive Psychology, 43*(1), 1–22.

Bowdle, B. F., & Gentner, D. (1997). Informativity and asymmetry in comparisons. *Cognitive Psychology, 34*(3), 244–286.

Bowerman, M., & Choi, S. (2001). Shaping meanings for language: Universal and language specific in the acquisition of spatial semantic categories. In M. Bowerman & S. C. Levinson (Eds.), *Language acquisition and cognitive development* (pp. 475–511). New York: Cambridge University Press.

Casasola, M. (2005). Can language do the driving? The effect of linguistic input on infants' categorization of support spatial relations. *Developmental Psychology, 41*(1), 183–192.

Casasola, M., & Cohen, L. B. (2002). Infant categorization of containment, support and tight-fit spatial relationships. *Developmental Science, 5*(2), 247–264.

Casasola, M., Cohen, L. B., & Chiarello, E. (2003). Six-month-old infants' categorization of containment spatial relations. *Child Development, 74*(3), 679–693.

Casler, K., & Kelemen, D. (2005). Young children's rapid learning about artifacts. *Developmental Science, 8*(6), 472–480.

Choi, S. (2006). Influence of language-specific input on spatial cognition: Categories of containment. *First Language, 26*(2), 207–232.

Choi, S., & Bowerman, M. (1991). Learning to express motion events in English and Korean: The influence of language-specific lexicalization patterns. *Cognition, 41*(1-3), 83–121.

Choi, S., McDonough, L., Bowerman, M., & Mandler, J. M. (1999). Early sensitivity to language-specific spatial categories in English and Korean. *Cognitive Development, 14*(2), 241–268.

Chomsky, N. (1986). *Knowledge of language: Its nature, origin and use*. New York, NY: Praeger.

Davidoff, J., Davies, I., & Roberson, D. (1999). Colour categories in a stone-age tribe. *Nature, 398*, 203–204.

Diesendruck, G., Markson, L., & Bloom, P. (2003). Children's reliance on creator's intent in extending names for artifacts. *Psychological Science, 14*(2), 164–168.

Gennari, S. P., Sloman, S. A., Malt, B. C., & Fitch, W. T. (2002). Motion events in language and cognition. *Cognition, 83*(1), 49–79.

Hespos, S. J., & Spelke, E. S. (2004). Conceptual precursors to language. *Nature, 430*(6998), 453–456.

Holyoak, K. J., & Gordon, P. C. (1983). Social reference points. *Journal of Personality and Social Psychology, 44*(5), 881–887.

Huttenlocher, J., Hedges, L. V., & Duncan, S. (1991). Categories and particulars: Prototype effects in estimating spatial location. *Psychological Review, 98*(3), 352–376.

Imai, M., & Gentner, D. (1997). A cross-linguistic study of early word meaning: Universal ontology and linguistic influence. 1997. *Cognition, 62*(2), 169–200.

Karylowski, J. J. (1990). Social reference points and accessibility of trait-related information in self-other similarity judgments. *Journal of Personality and Social Psychology, 58*(6), 975–983.

Kawachi, K. (2007). Korean putting verbs do not contrast space contrastively in terms of "tightness of fit". *Lingua, 117*, 1801–1820.

Keil, F. C. (1989). *Concepts, kinds, and cognitive development*. Cambridge, MA: MIT Press.

Kemler Nelson, D. G., Herron, L., & Holt, M. B. (2003). The sources of young children's name innovations for novel artifacts. *Journal of Child Language, 30*(4), 823–843.

Kuhl, P. K. (1998). Effects of language experience on speech perception. *Journal of the Acoustical Society of America, 103*(5), 2931.

Landau, B. (in press). Space in semantics and cognition: Three themes. In C. Maienborn, K. von Heusinger, & P. Portner (Eds.), *Semantics: An international handbook of natural language meaning*. Berlin: Mouton de Gruyter.

Leslie, A. M. (1984). Infant perception of a manual pick-up event. *British Journal of Developmental Psychology, 2*(1), 19–32.

Levinson, S. C. (1996). Relativity in spatial conception and description. In J. J. Gumperz & S. C. Levinson (Eds.), *Rethinking linguistic relativity* (pp. 177–202). New York, NY: Cambridge University Press.

Li, P., & Gleitman, L. (2002). Turning the tables: Language and spatial reasoning. *Cognition, 83*(3), 265–294.

Lucy, J. A. (1992). *Grammatical categories and cognition: A case study of the linguistic relativity hypothesis*. Cambridge: Cambridge University Press.

Malt, B. C., Sloman, S. A., Gennari, S., Shi, M., & Wang, Y. (1999). Knowing versus naming: Similarity and the linguistic categorization of artifacts. *Journal of Memory and Language, 40*(2), 230–262.

Matan, A., & Carey, S. (2001). Developmental changes within the core of artifact concepts. *Cognition, 78*(1), 1–26.

McDonough, L., Choi, S., & Mandler, J. M. (2003). Understanding spatial relations: Flexible infants, lexical adults. *Cognitive Psychology, 46*(3), 229–259.

Medin, D. L., & Waxman, S. R. (2007). Interpreting asymmetries of projection in children's inductive reasoning. In A. Feeney & E. Heit (Eds.), *Inductive reasoning*. New York, NY: Cambridge University Press.

Munnich, E., Landau, B., & Dosher, B. A. (2001). Spatial language and spatial representation: A cross-linguistic comparison. *Cognition, 81*(3), 171–207.

Needham, A., & Baillargeon, R. (1993). Intuitions about support in 4.5-month-old infants. 1993. *Cognition, 47*(2), 121–148.

Norbury, H. & Waxman, S. R. (in preparation). English- and Korean-speakers' verbal descriptions of fit.

Nosofsky, R. M. (1991). Stimulus bias, asymmetric similarity, and classification. *Cognitive Psychology, 23*(1), 94–140.

Papafragou, A., Massey, C., & Gleitman, L. (2002). Shake, rattle, 'n' roll: The representation of motion in language and cognition. *Cognition, 84*(2), 189–219.

Rips, L. J. (1975). Inductive judgments about natural categories. *Journal of Verbal Learning & Verbal Behavior, 14*(6), 665–681.

Rosch, E. (1975). Cognitive reference points. *Cognitive Psychology, 7*(4), 532–547.

Sadalla, E. K., Burroughs, W. J., & Staplin, L. J. (1980). Reference points in spatial cognition. *Journal of Experimental Psychology: Human Learning & Memory, 6*(5), 516–528.

Slobin, D. I. (1996). From "thought and language" to "thinking for speaking". In J. Gumperz & S. C. Levinson (Eds.), *Rethinking linguistic relativity* (pp. 70–96). New York: Cambridge University Press.

Treisman, A., & Souther, J. (1985). Search asymmetry: A diagnostic for preattentive processing of separable features. *Journal of Experimental Psychology: General, 114*(3), 285–310.

Tversky, A. (1977). Features of similarity. *Psychological Review, 84*(4), 327–352.

Werker, J. F., & Tees, R. C. (1984). Cross-language speech perception: Evidence for perceptual reorganization during the first year of life. *Infant Behavior & Development, 7*(1), 49–63.

Whorf, B. L. (1956). In J. B. Carroll (Ed.), *Language, thought, and reality: Selected writings of Benjamin Lee Whorf*. Oxford, England: Technology Press of MIT.